CLAIMS

What is claimed is:

1. A film comprising a nano-crystalline diamond matrix, wherein the nano-crystalline diamond matrix is substantially free of graphite inclusions.

2. The film of claim 1, wherein the infrared absorption peaks between 3200 cm^{-1} and 2800 cm^{-1} of the nano-crystalline diamond matrix are at 2930 cm^{-1} and 2880 cm^{-1} only.

3. The film of claim 1, wherein the nano-crystalline diamond matrix has no infrared absorption peaks at 2980 cm^{-1} and 3100 $^{-1}$.

4. The film of claim 1, wherein the nano-crystalline diamond matrix has a hardness of at least 60 GPa.

5. The film of claim 1, wherein the film is between 40 nm and 1000 nm thick.

6. The film of claim 1, wherein the film is thermally stable at 450 °C or higher.

7. The film of claim 1, wherein the film has an average root mean square surface roughness of less than 5.00 nm.

8. A substrate at least partially coated with a film comprising a nano-crystalline diamond matrix, wherein the nano-crystalline diamond matrix is substantially free of graphite inclusions.

9. The substrate of claim 8, wherein the infrared absorption peaks between 3200 cm^{-1} and 2800 cm^{-1} of the nano-crystalline diamond matrix are at 2930 cm^{-1} and 2880 cm^{-1} only.

10. The substrate of claim 8, wherein the nano-crystalline diamond matrix has no infrared absorption peaks at 2980 cm^{-1} and 3100 $^{-1}$.

11. The substrate of claim 8, wherein the nano-crystalline diamond matrix has a hardness of at least 60 GPa.

12. The substrate of claim 8, wherein said film has tensile stress.

13. The substrate of claim 8, wherein said film has compressive stress.

14. The substrate of claim 8, wherein said film is free of mechanical stress.

15. The substrate of claim 8, wherein said film is between 40 nm and 1000 nm thick.

16. The substrate of claim 8, wherein the film is thermally stable at 450 °C or higher.

17. The substrate of claim 8, wherein the film has an average root mean square surface roughness of less than 5.00 nm.

18. A method of depositing a film on a substrate comprising:

(a) providing a plasma chamber containing a substrate, a radio frequency electrode, and a gas mixture,

wherein the gas mixture comprises a hydrocarbon gas having a first partial pressure and a noble gas having a second partial pressure;

(b) inducing a plasma in said gas mixture by transmitting a radio frequency from the radio frequency electrode;

(c) producing a DC bias voltage on the radio frequency electrode; and

(d) operating at a DC bias voltage that substantially precludes the formation of a plasma ion capable of causing a region of a nano-crystalline diamond matrix within a forming film to allotrope when the plasma ion collides with the film.

19. The method of claim 18, wherein said noble gas comprises helium or neon.

20. The method of claim 18, wherein said hydrocarbon gas comprises ethylene.

21. The method of claim 18, wherein said radio frequency is between 0.5 MHz and 1 GHz.

22. The method of claim 18, wherein said DC bias voltage is less than or equal to 60 volts.

23. The method of claim 18, wherein the film produced comprises a nano-crystalline diamond matrix, wherein the nano-crystalline diamond matrix is substantially free of graphite inclusions.

24. The method of claim 18, wherein the film produced comprises a nano-crystalline diamond matrix, wherein the infrared absorption peaks between 3200 cm^{-1} and 2800 cm^{-1} of the nano-crystalline diamond matrix are at 2930 cm^{-1} and 2880 cm^{-1} only.

25. The method of claim 18, wherein the film produced comprises a nano-crystalline diamond matrix, wherein the nano-crystalline diamond matrix has no infrared absorption peaks at 2980 cm^{-1} and 3100 $^{-1}$.

26. The method of claim 18, wherein the film produced comprises a nano-crystalline diamond matrix, wherein the nano-crystalline diamond matrix has a hardness of at least 60 GPa.

27. The method of claim 18, wherein the film produced comprises a nano-crystalline diamond matrix, wherein the nano-crystalline diamond matrix is thermally stable at 450 °C or higher.

28. The method of claim 18, wherein the ratio of the first partial pressure to the second partial pressure produces a film free of mechanical stress.

29. The method of claim 18, wherein the ratio of the first partial pressure to the second partial pressure produces a film having compressive stress.

30. The method of claim 18, wherein the ratio of the first partial pressure to the second partial pressure produces a film having tensile stress.

31. The method of claim 18, wherein the film produced has an average root mean square surface roughness of less than 5.00 nm.